

The Smithsonian Astrophysical Observatory SOLAR CONSTANT Database

The Smithsonian Astrophysical Observatory (APO) gathered solar constant data during at least 49 years of solar monitoring. The solar constant is the total amount of energy received from the sun per unit time per unit area exposed normally to the Sun's rays at the average Sun Earth distance and outside of the Earth's atmosphere. The purpose of this APO project was to determine an accurate value for this energy flux and to determine whether or not the Sun's total energy output is indeed constant in time.

Variability in the solar constant would have profound effects on terrestrial climate. Some of the phenomenon which are possibly related to solar flux variations are the advance and retreat of glaciers, occurrence of droughts, water levels in rivers and lakes, and changes in meridional sea level pressure. Whether or not the APO data does in fact show any variation in solar output has been a subject of considerable controversy. Many investigators claimed the measurements revealed real solar variations. Others felt the measurements gave no such proof.

One study, of many, done to correlate solar constant variation and solar activity used the monthly mean "long" method solar constant values measured at all stations and the monthly mean Wolf sunspot number. The linear least squares fit gives the value of the solar constant as

$$S = [(1.94506 \pm .00059) + (.000008 \pm 000008)R]$$

where S is the solar constant and R is the sunspot number.

Two basic measurement techniques were used, the "long" method and the "short" method. The "long" method utilized an instrument called a pyrliometer that measured directly the total irradiance of the Sun. Combining this with a spectrobolometer which photographically recorded the spectrum of the Sun, absolute values of the spectral irradiance could be deduced. Taking absolute irradiance at several air mass values (zenith angles) an extrapolation to zero air mass could be made. The extraterrestrial solar spectrum and hence solar constant were thereby determined.

The "short" method of monitoring the solar constant required considerably less time to compute and eliminated problems of varying atmospheric transmission. A pyranometer (aureole brightness meter) measures the brightness of the sky in a doughnut shaped ring about the Sun. This method relied on a "function" of precipitable water and pyranometer measurements to give a value for atmospheric transmission.

The validity of the data prior to 1923 was questioned by many, including the APO director from 1906 to 1944, Charles Greeley Abbot. Problems ranging from volcanoes to the invention of the improved measuring devices made this part of the data set of limited use. The remaining 31 years of data have been the subject of a controversy of interpretation as mentioned earlier. Abbot and his APO staff claimed that the data showed a 0.2% increase in solar output from 1923 to 1954. Others argued that unconventional data manipulation made such a conclusion erroneous. Notwithstanding all of the short comings and controversy inherent in the

data, this program is the longest and most carefully conducted solar radiation program made so far this century.

The data are stored in 47 files. Files 1-15 are generally formatted as shown in FORMAT A below. However the information stored in columns 13-16, 21-25, and 71-75 varies from file to file. Depending on which of these first 15 files are accessed, these columns may contain: water vapor pressure divided by 100, apparent atmospheric transmission, atmospheric transmission; apparent solar constant, long method solar constant, short method solar constant, precipitable water, pyr heliometry at 2.0 air mass, solar constant corrected for constant water vapor, solar constant corrected for zero water vapor. The wavelengths at which atmospheric transmission values are given also vary among these first 15 files.

FORMAT B shows how the remaining files 16-47 are formatted. The following table lists each file with its corresponding station location and dates.

FILE NUMBER	STATION LOCATION	MONITORING PERIOD
=====	=====	=====
1	Calama, Chile	1918-1920
2	Mount Harqua Hala, Arizona	1920-1925
3	Hump Mountain, North Carolina	1917-1918
4	Miami, Florida	1948
5	Mount Montezuma, Chile	1920-1930
6	Mount Montezuma, Chile	1940-1948
7	Mount Brukkaros, S.W. Africa	1926-1930
8	Mount St. Katherine, Egypt	1934-1937
9	Mount Wilson, California	1905-1906
10	Mount Wilson, California	1908-1911
11	Mount Wilson, California	1912-1920
12	Table Mountain, California	1925-1930
13	Table Mountain, California	1940-1950
14	Burro Mountain, New Mexico	1940-1945
15	Washington D.C.	1902-1907
16-47	Mount Montezuma, Chile	
	Table Mountain, California	
	Burro Mountain, New Mexico	
	Mount St. Katherine, Egypt	1923-1954

FORMAT A

Column	Format	Value
=====	=====	=====
1	A1	Site(C)
3- 6	I4	Year
7-10	A4	Month - alphabetic
11-12	I2	Date
13-16	F4.2	Water vapor pressure
17-20	F4.1	Precipitable water
21-25	5X	Blank
26-29	F4.3	Atmospheric transmission - 0.335 microns wavelength
30-33	F4.3	Atmospheric transmission - 0.403 microns wavelength
34-37	F4.3	Atmospheric transmission - 0.460 microns wavelength

38-41	F4.3	Atmospheric transmission - 0.511 microns wavelength
42-45	F4.3	Atmospheric transmission - 0.630 microns wavelength
46-49	F4.3	Atmospheric transmission - 0.702 microns wavelength
50-53	F4.3	Atmospheric transmission - 0.830 microns wavelength
54-57	F4.3	Atmospheric transmission - 1.008 microns wavelength
58-61	F4.3	Atmospheric transmission - 1.244 microns wavelength
62-65	F4.3	Atmospheric transmission - 1.610 microns wavelength
66-70	F5.3	Solar constant E ₀
77-80	A4	Grade

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 FORMAT B

Column	Format	Value
=====	=====	
1- 4	I4	Year
6- 7	I2	Month
9-10	I2	Day
12-13	I2	Hour
15-16	A2	Station abbreviation - M = Mount Montezuma, Chile T = Table Mountain, California TY = Burro Mountain, New Mexico K = Mount St. Katherine, Egypt
17-19	I3	Air mass - must be divided by 100.
20-23	F4.1	Precipitable water
25	A1	Group designation
27-30	I4	Function
32-34	I3	Pyrheliometry - must be divided by 1000 and added to 1.
36-38	I3	Pyranometry - must be divided by 10000.
40-41	I2	Solar constant - must be divided by 1000 and added to 1.
43	A1	Grade
45-46	I2	Best estimate of solar constant for the day - must be divided by 1000 and added to 1.9.